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Canada



Using Earth Observation to Monitor Drought Characteristics & Impacts in Canada

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*North American Drought Monitor Forum
Calgary, Alberta, May 1-3, 2018*

Earth Observation of Water Cycle

- Over the last decade a proliferation of missions and data sets dedicated to monitoring water cycle over land areas
 - *SMAP/SMOS dedicated soil moisture missions*
 - *“Long term” vegetation health records from MODIS/AVHRR*
 - *Global Precipitation Mission (GPM)*
 - *GOES thermal/optical remote sensing over North America*
 - *GRACE & GRACE follow on gravity mission*
 - *Landsat – Sentinel 1 (Radar) & 2 (Optical) sensors, operational at 10-30m resolution*
- records (15+ years) are now more common
- there is a need for better assessment of how these reflect different time scales of drought over different landscapes, and how errors in satellite data records impact interpretation of these data sets
- Potential to use these data sets to better understand drought characteristics by linking observations of different aspects of water cycle together

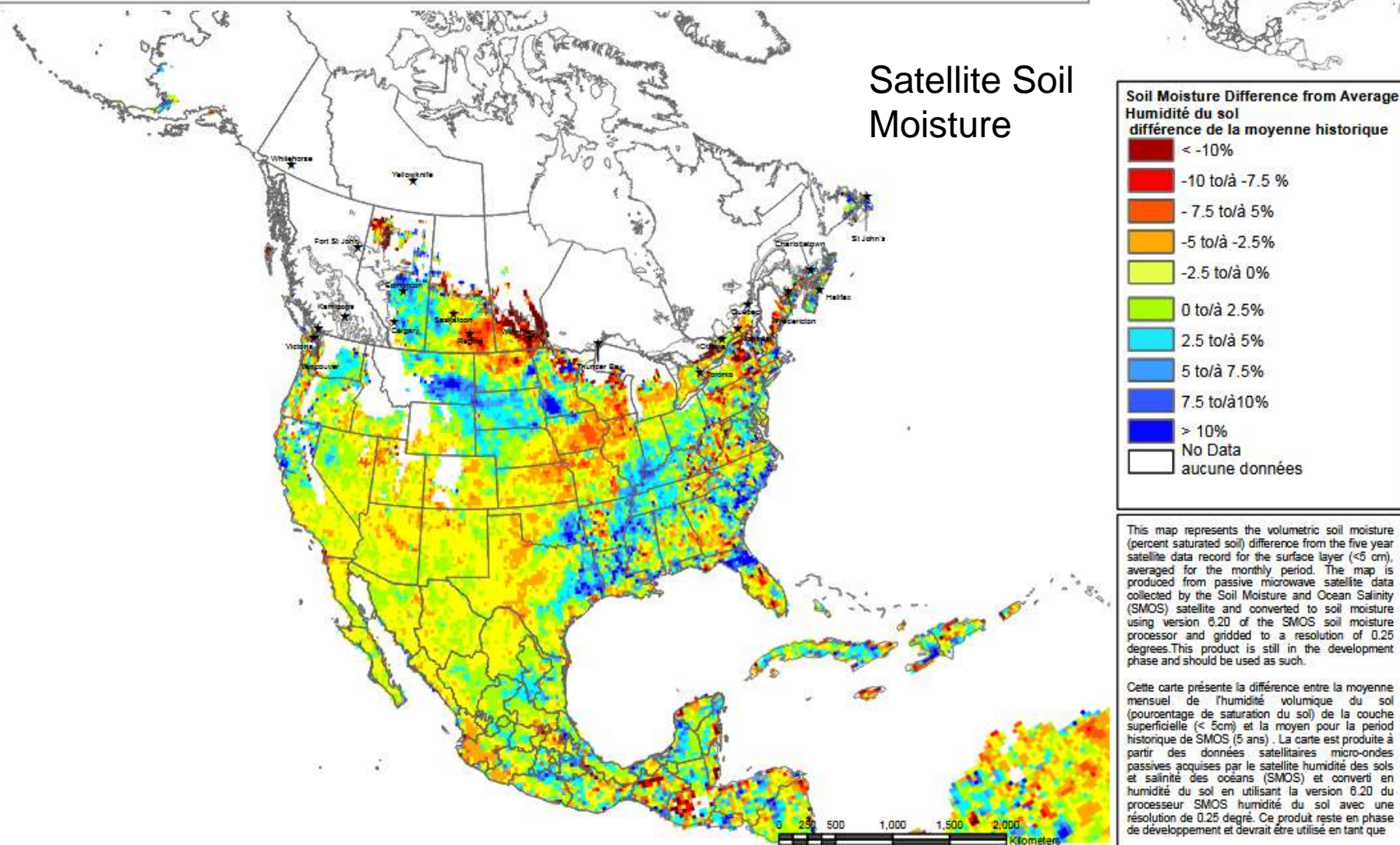


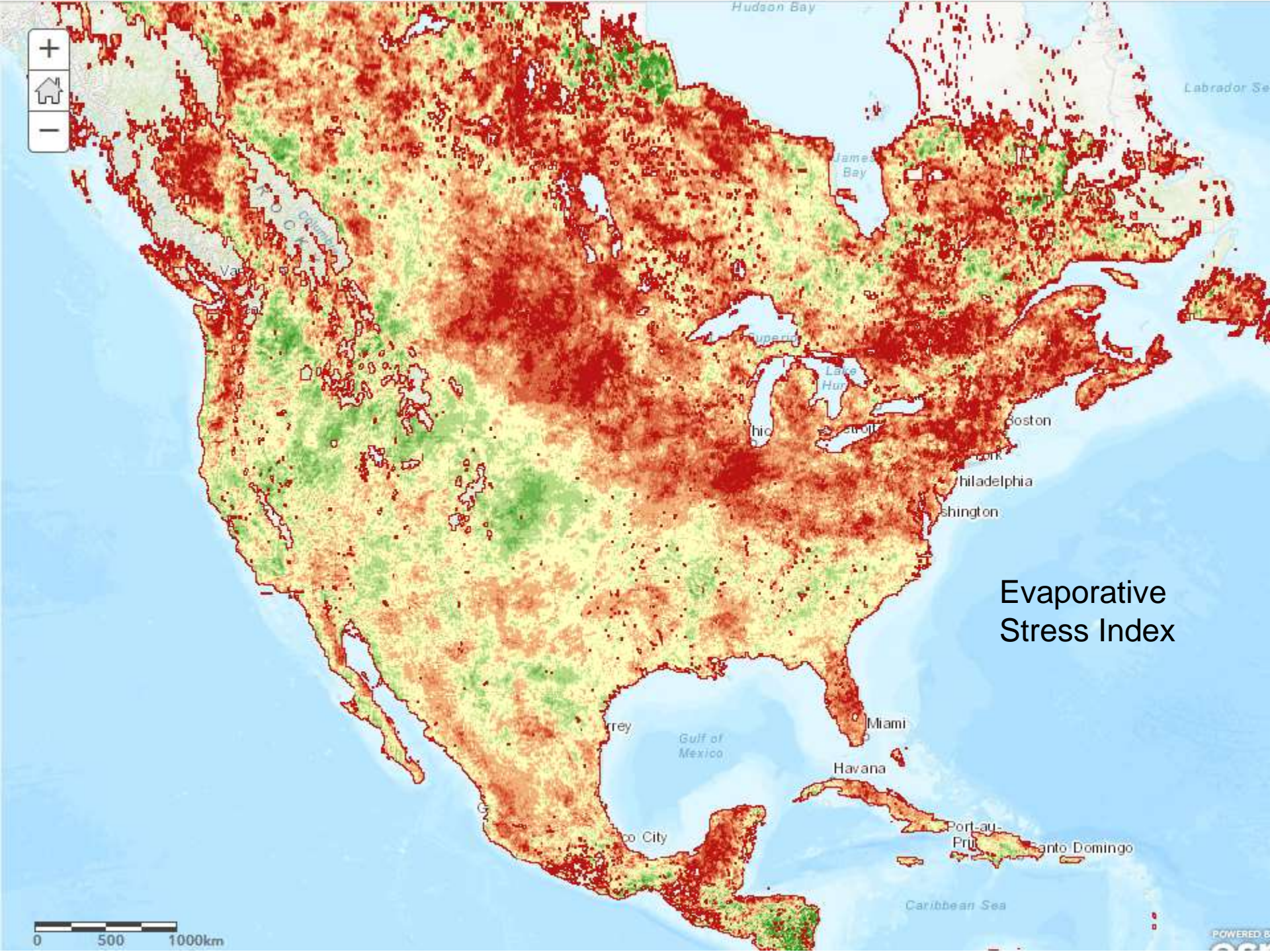
Difference from Long Term Average, Percent Saturated Surface Soil Moisture from SMOS Satellite
Pourcentage de saturation en eau de la surface du sol obtenu des données satellite SMOS,
la différence entre les conditions actuelles et la moyenne

April 1 - 30, 2018 / 1 - 30 avril, 2018



Satellite Soil Moisture



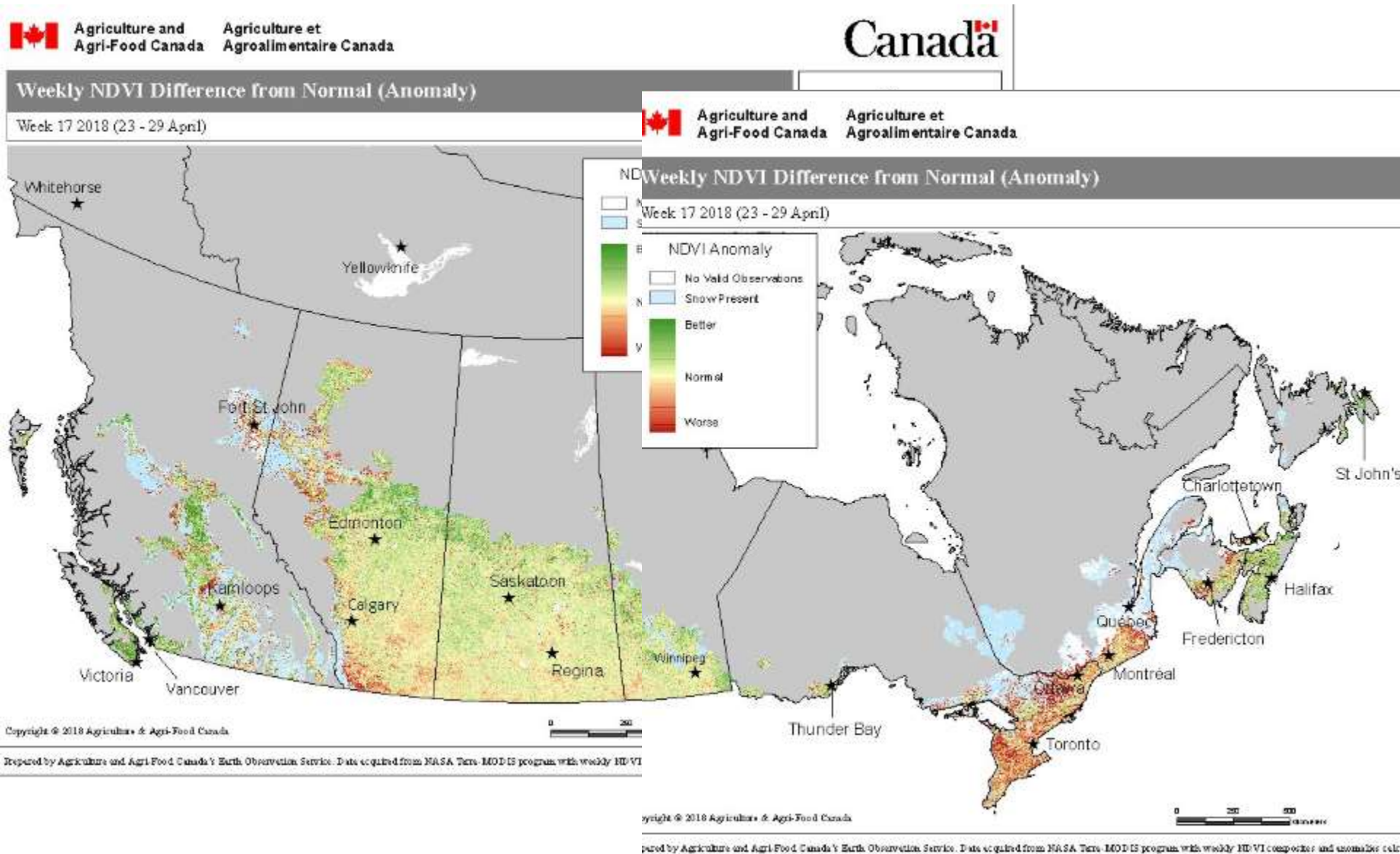


Evaporative
Stress Index

0 500 1000km

POWERED BY

MODIS NDVI Anomalies



Remote Sensing of Drought & Drought Impacts

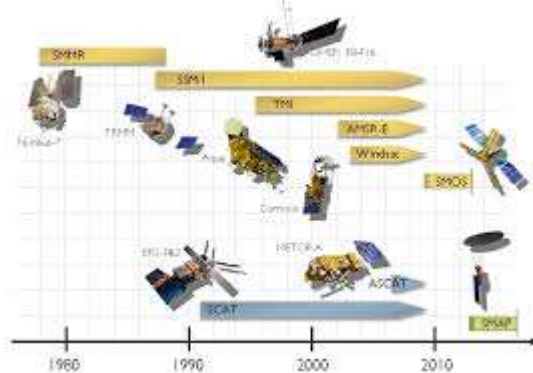


MODIS Normalized Difference Vegetation Index (NDVI) 2000 – present
230m resolution
(Agriculture and Agri-Food Canada & USGS)



GOES Evaporative Stress Index (ESI) 2001 – present
10km resolution
(NOAA – Martha Anderson and Chris Hain)

All remote sensing data-based data sets were converted to relative values with a mean of zero

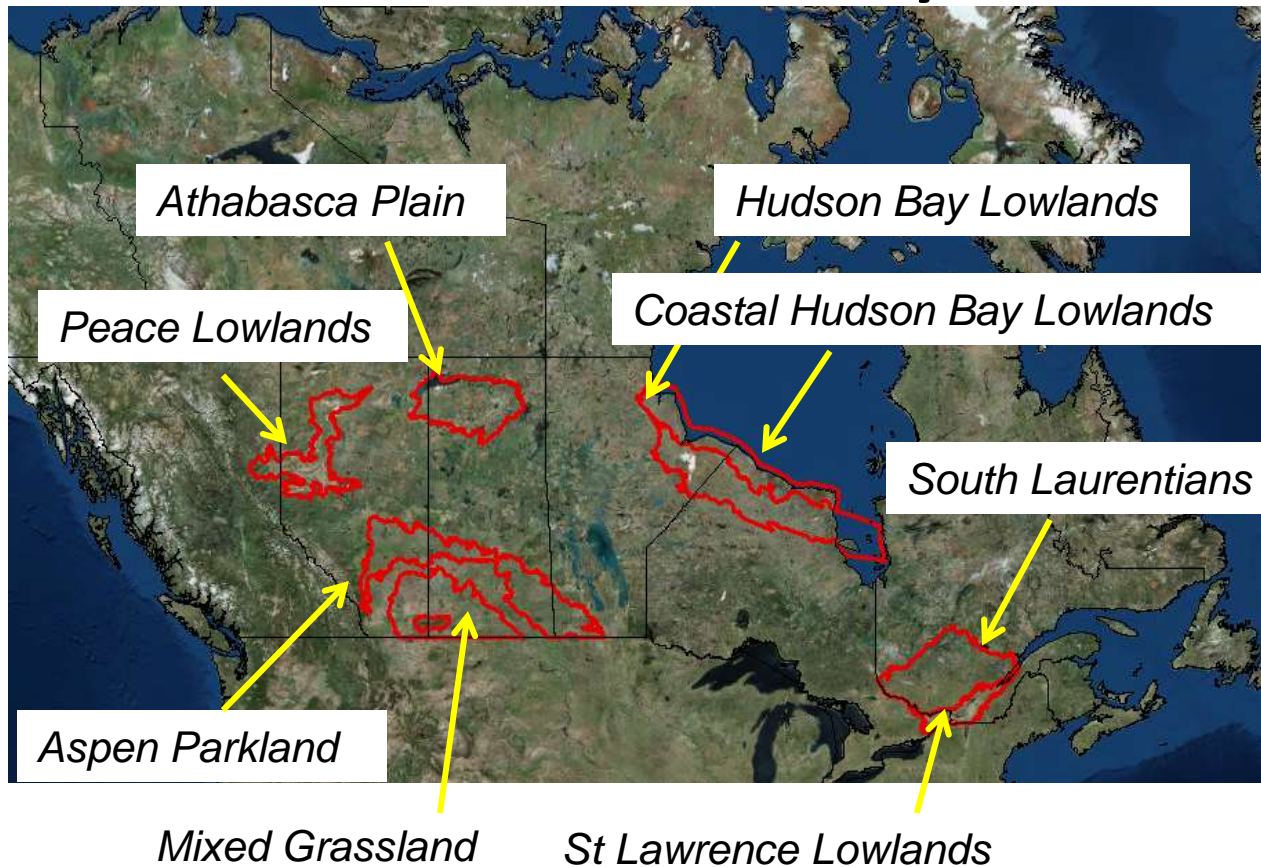


ESA CCI Soil Moisture 1979 – present
25km resolution
(European Space Agency Climate Change Initiative)



GRACE Total Water Storage 2002 – 2017
1 degree resolution
(NASA & Natural Resources Canada)

Study Area



Selected Eight EcoRegions in Canada covering four dominant land cover types:

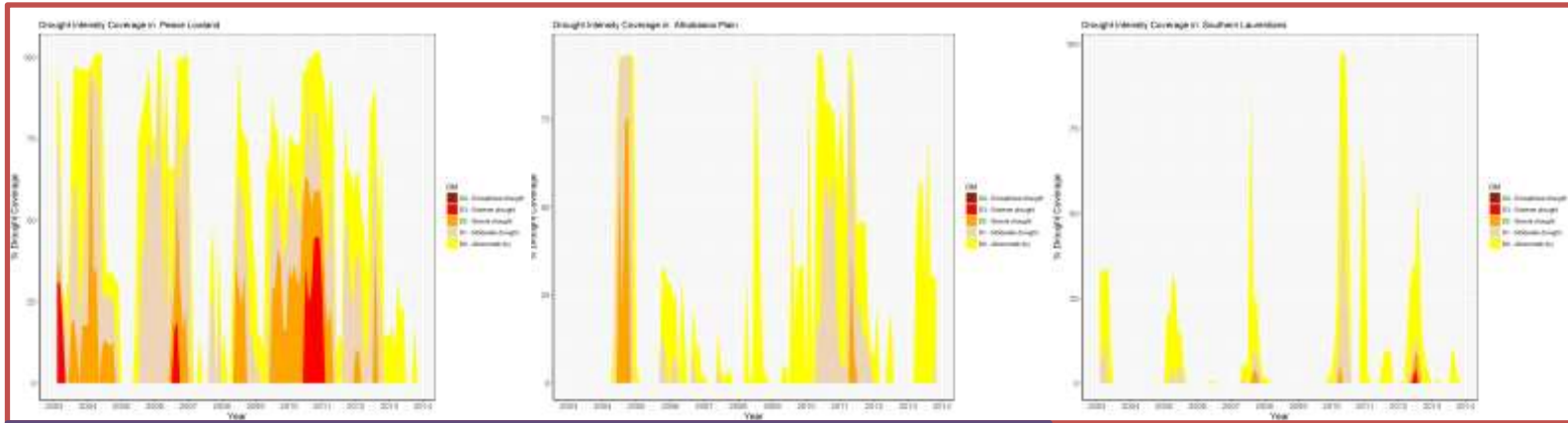
- Cropland
- Forest
- Wetland
- Grassland

Areas were selected based on occurrence of drought within the last 15 years of assessment by the Canadian Drought Monitor

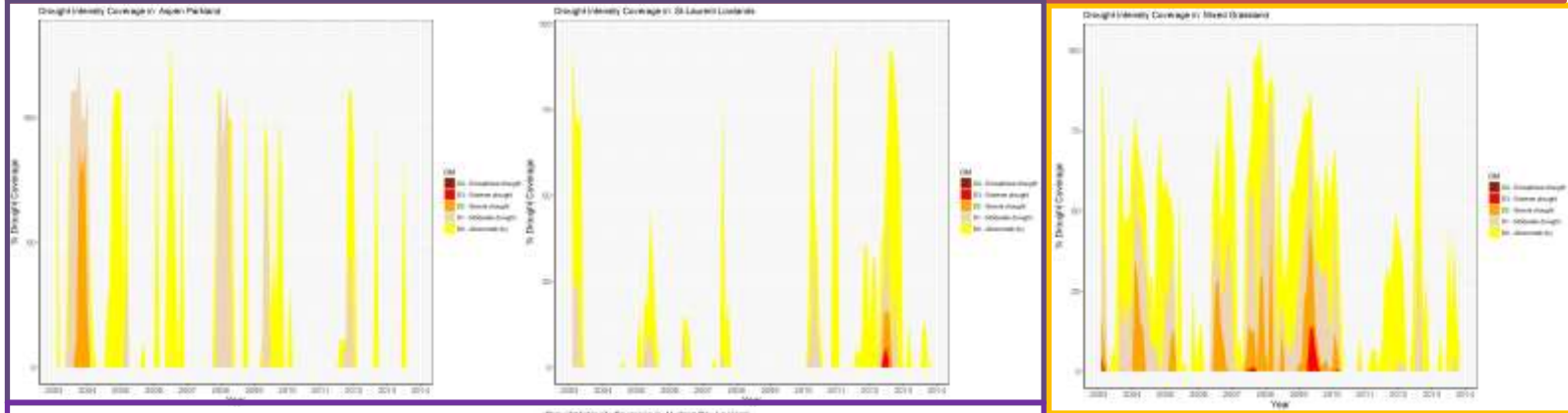
Assessed earth observations over 2003-2016 period for dominant land cover type within each region.

Drought Conditions Over the Study Period

Forest

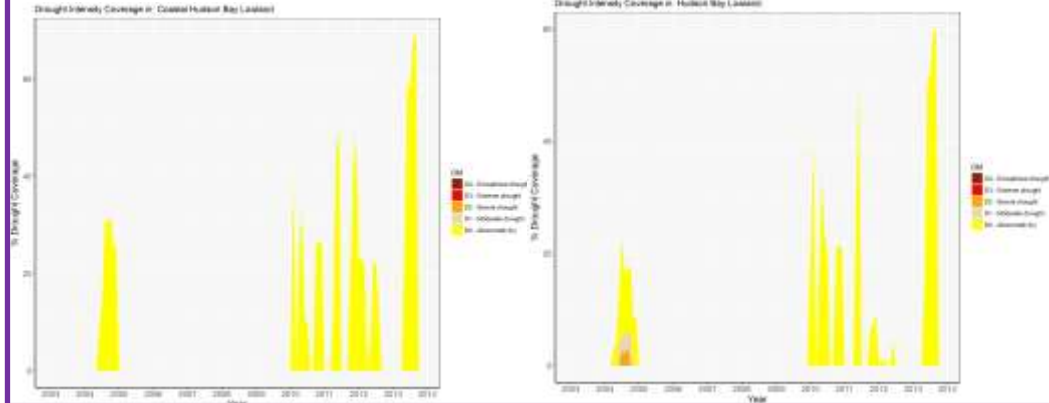


Cropland

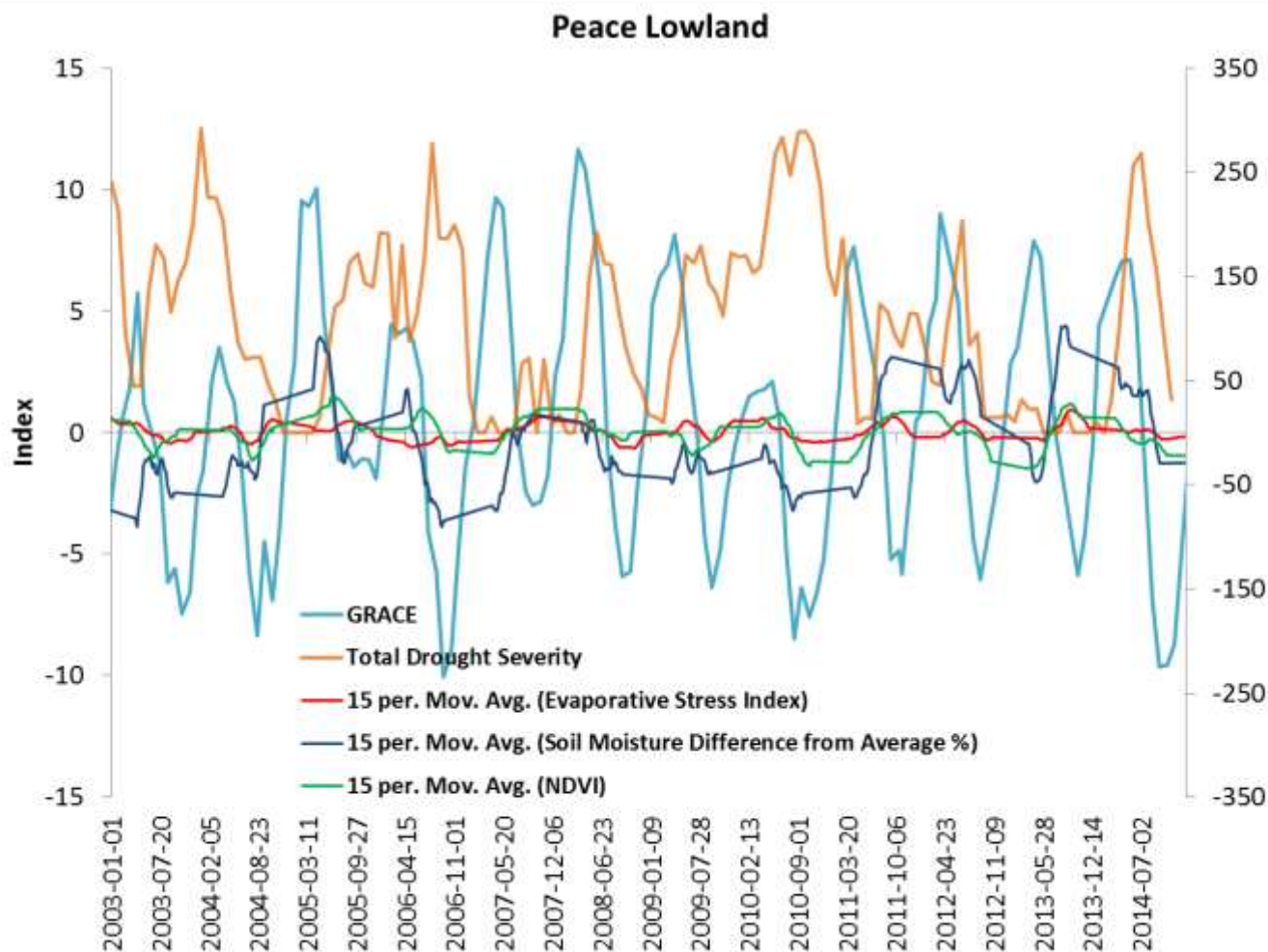


Grassland

Wetland



Comparing Scales and timing of Drought



-ESI fluctuates most, difficult to distinguish short term/long term drought

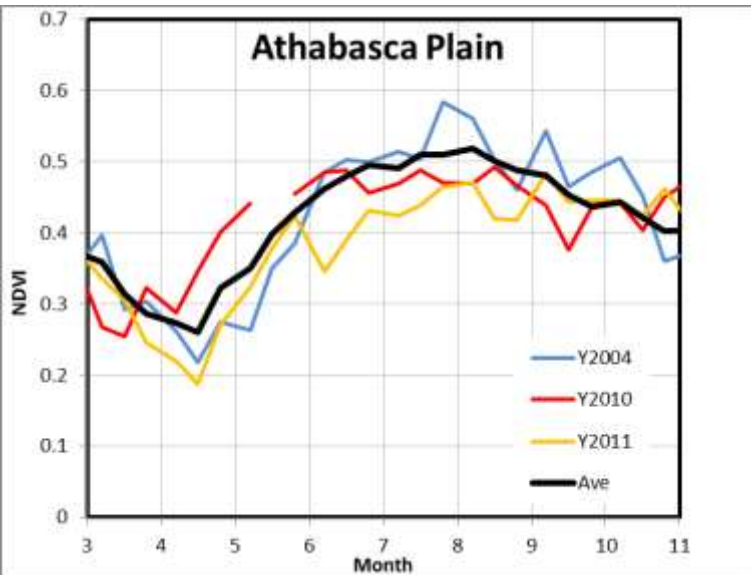
-SMDA fluctuates in time but temporal averages show early signs of drought onset and capture some nuance in severity

- GRACE follows DM most closely, droughts lasting more than one season show annual cycles of recharge but recharge is less in multi-season droughts

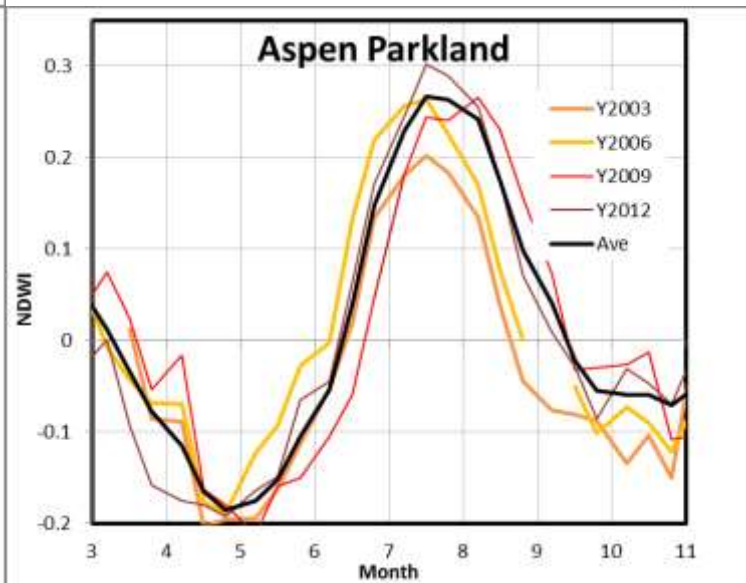
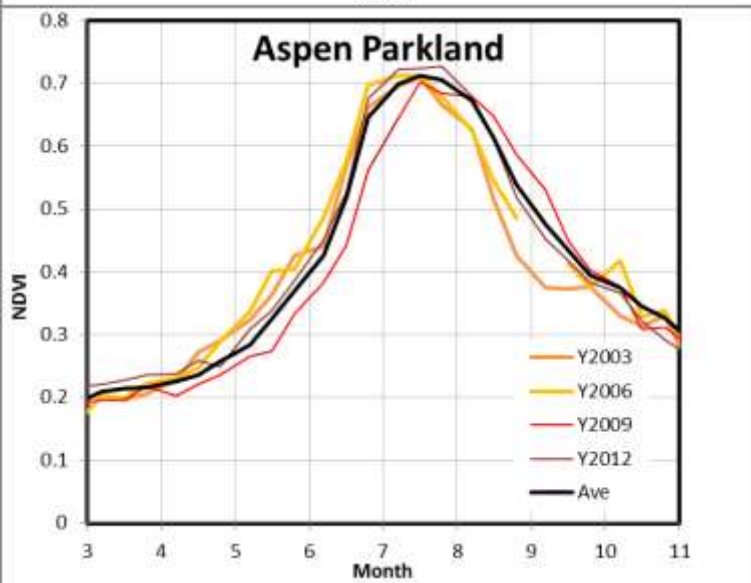
- NDVI tends to trail drought peaks and not necessarily tied to drought events

Cropland > Grassland > Forest > Wetland

Vegetation Indices



- Individual NDVI curves in different years show lower than average conditions in drought years (particularly forested, wetland and grassland)
- NDWI shows more pronounced response than NDVI in drought years in cropland areas
- Response is lower than average seasonal values, changes in timing of peak greenness/greenness onset



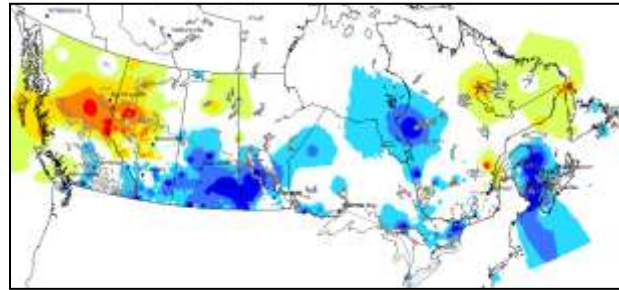
Using NDVI to Isolate Anomalies Due to Drought: Vegetation Drought Resonse Index (VegDRI)

Remote Sensing Component



Satellite Normalized
Difference Vegetation Index
(NDVI)

Climate Component













Standardized Precipitation Index (SPI)
Palmer Drought Severity Index (PDSI)

Biophysical Component



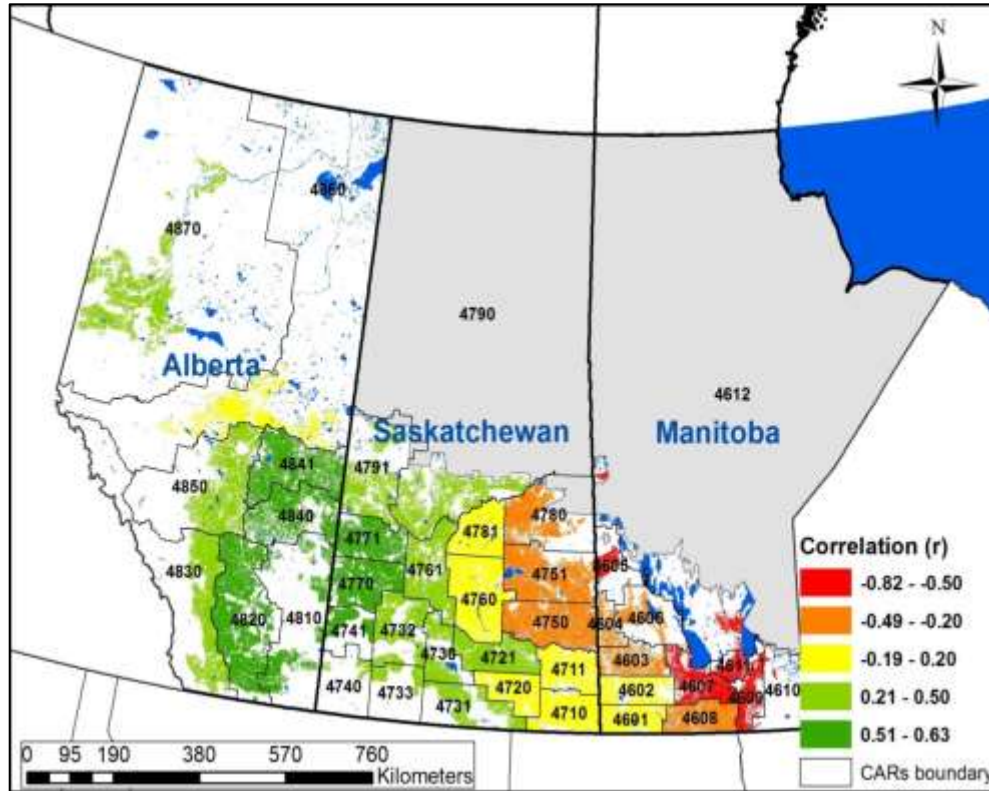
Land Cover
Irrigation
EcoZones
Soil Water Holding Capacity

Vegetation Condition

 Extreme Drought	 Unusually Moist
 Severe Drought	 Very Moist
 Moderate Drought	 Extreme Moist
 Pre-drought stress	 Out of Season
 Near Normal	 Water

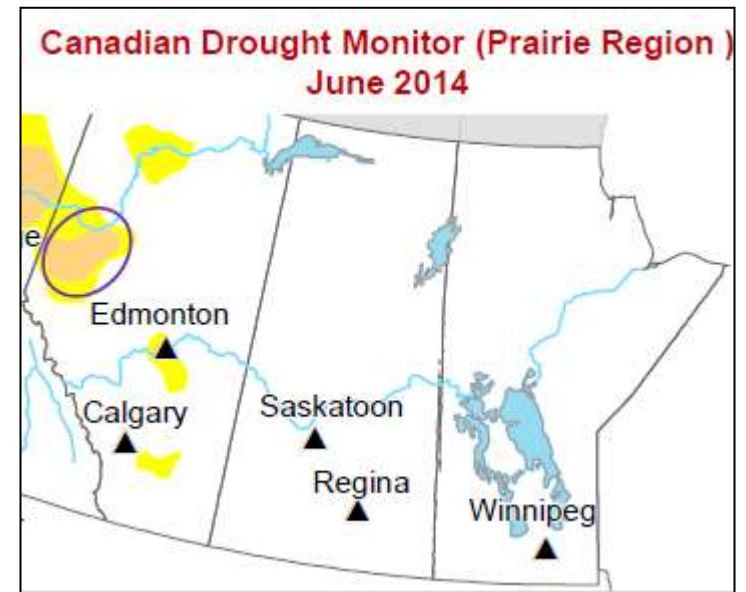
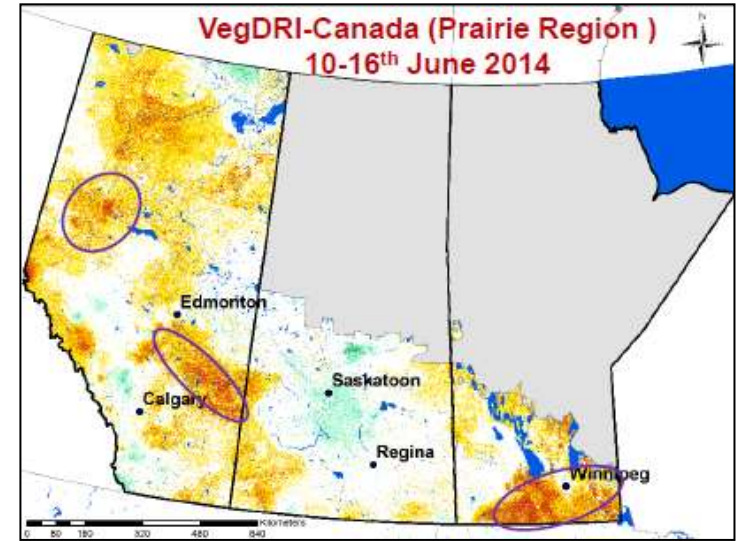
- Hybrid drought index that combines satellite observations of vegetation health with climate station information and land biophysical information
- Brown, J.F., Wardlow, B.D., Tadesse, T., Hayes, M.J., and Reed, B.C., 2008, The Vegetation Drought Response Index (VegDRI)—A new integrated approach for monitoring drought stress in vegetation: GIScience and Remote Sensing, v. 45, no. 1, p. 16-46*

VegDRI Canada Model Evaluation

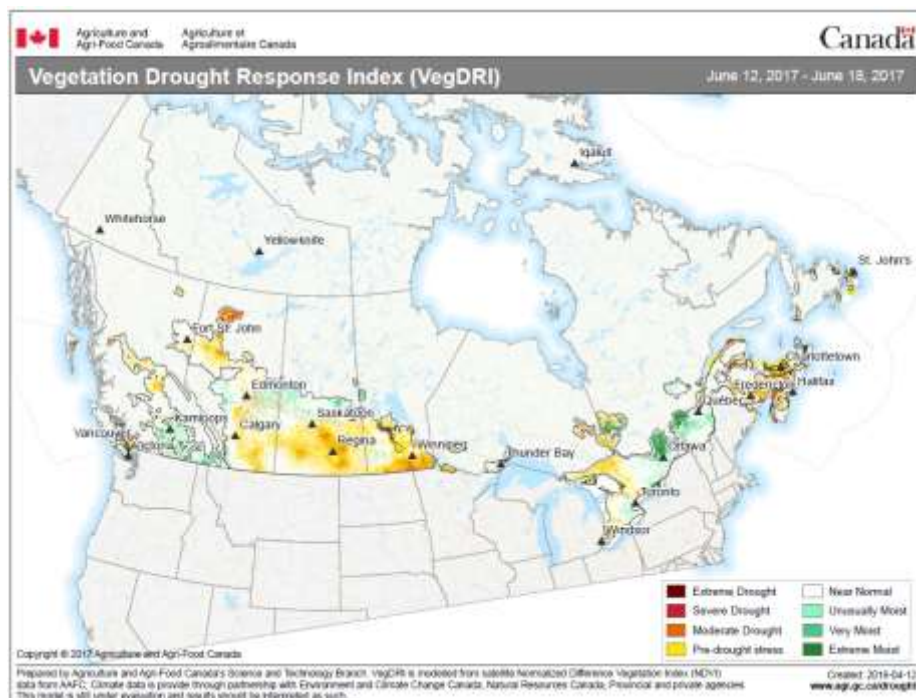


VegDRI ratings compared favourably to Canadian Drought Monitor assessment and showed good correlation with crop yields in areas where water stress is a dominant factor in determining yield.

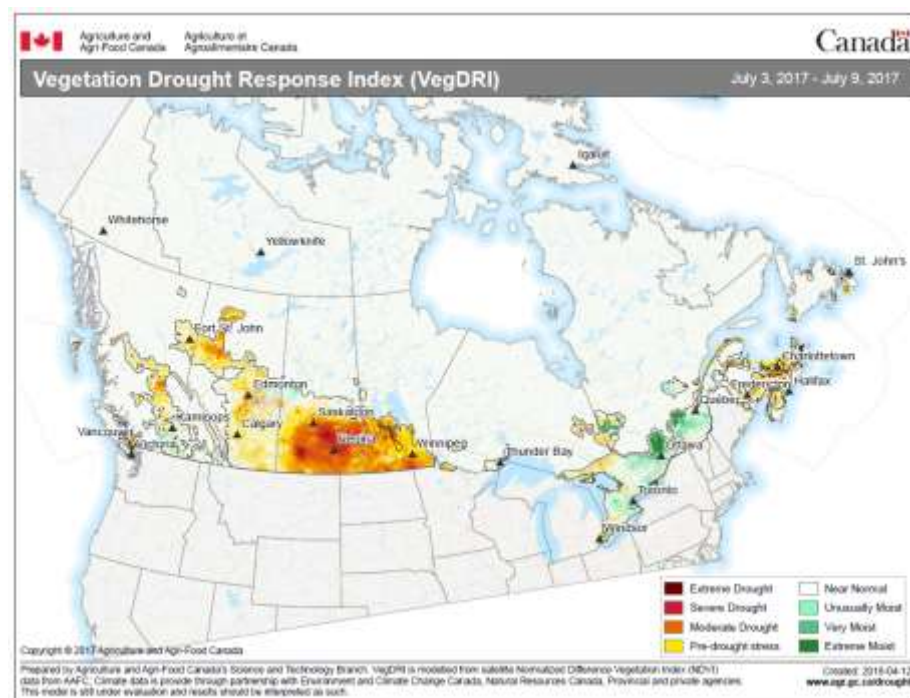
Tadesse, T., Champagne, C., Wardlow, B.D., Hadwen, T.A., Brown, J.F., Demisse, G.B., Bayissa, Y.A., & Davidson, A.M. (2017). Building the vegetation drought response index for Canada (VegDRI-Canada) to monitor agricultural drought: first results. *Giscience & Remote Sensing*, 1-28



Vegetation Drought Response Index (VegDRI) Canada



June 12 to 18, 2017



July 3 to July 9, 2017

- Canadian 7-Day MODIS NDVI as input using UNL models
- Worked with UNL to transfer the mapping methods to AAFC; will produce maps in 2017 and 2018 for evaluation with public release of data in later in 2018 or 2019

Canadian Crop Yield Forecaster



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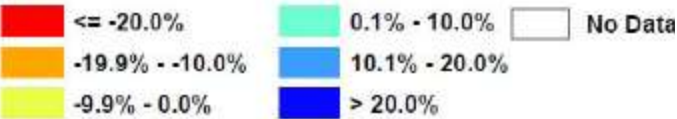
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Percent Departure of the Forecasted 2017 Canola Yield from the Mean Yield of 2012-2016

Forecast based on inputs for the period from May 1 to June 30



Percent Departure From Mean Yield of the Last Five Years



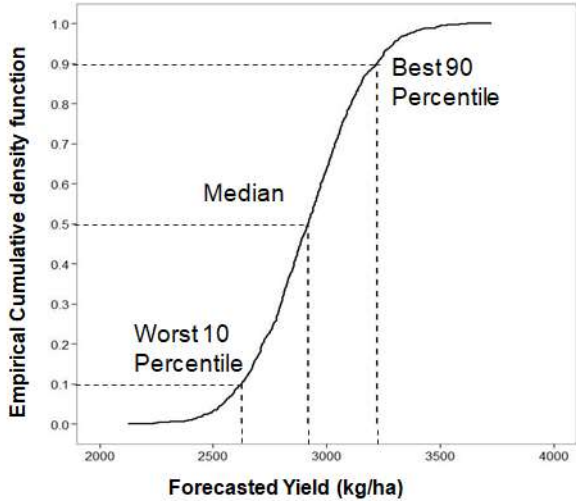
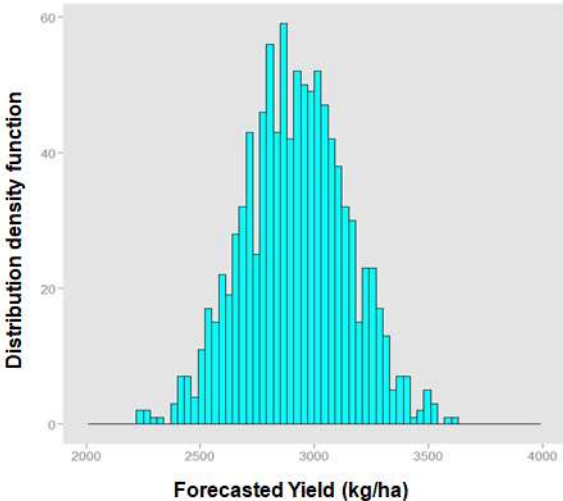
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Prepared by AgroClimate, Geomatics, and Earth Observation Division of Agriculture and Agri-Food Canada.

Inputs:

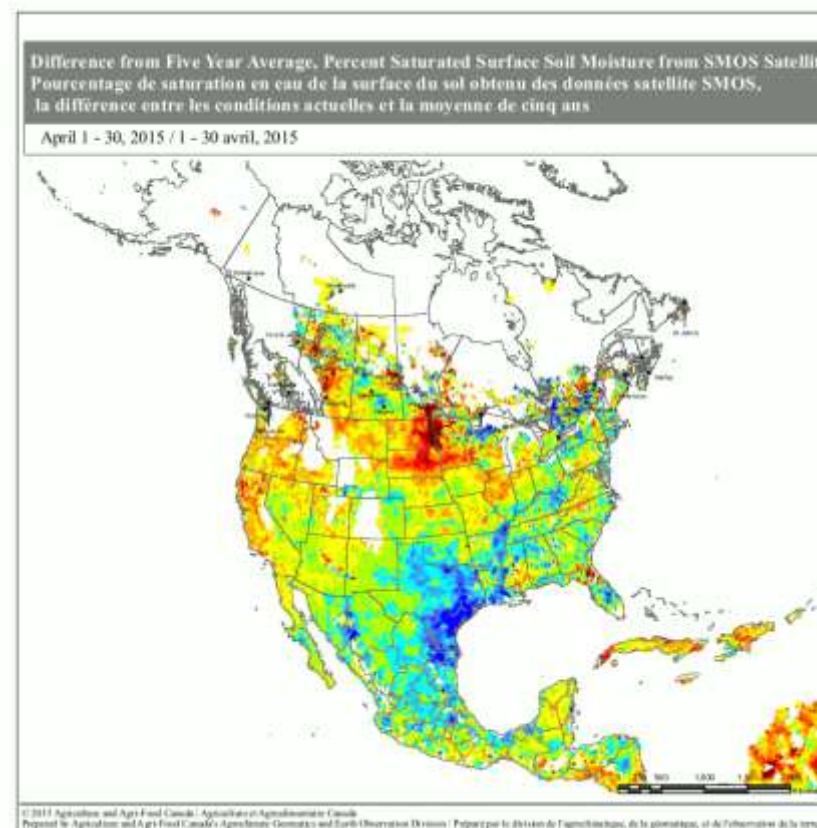
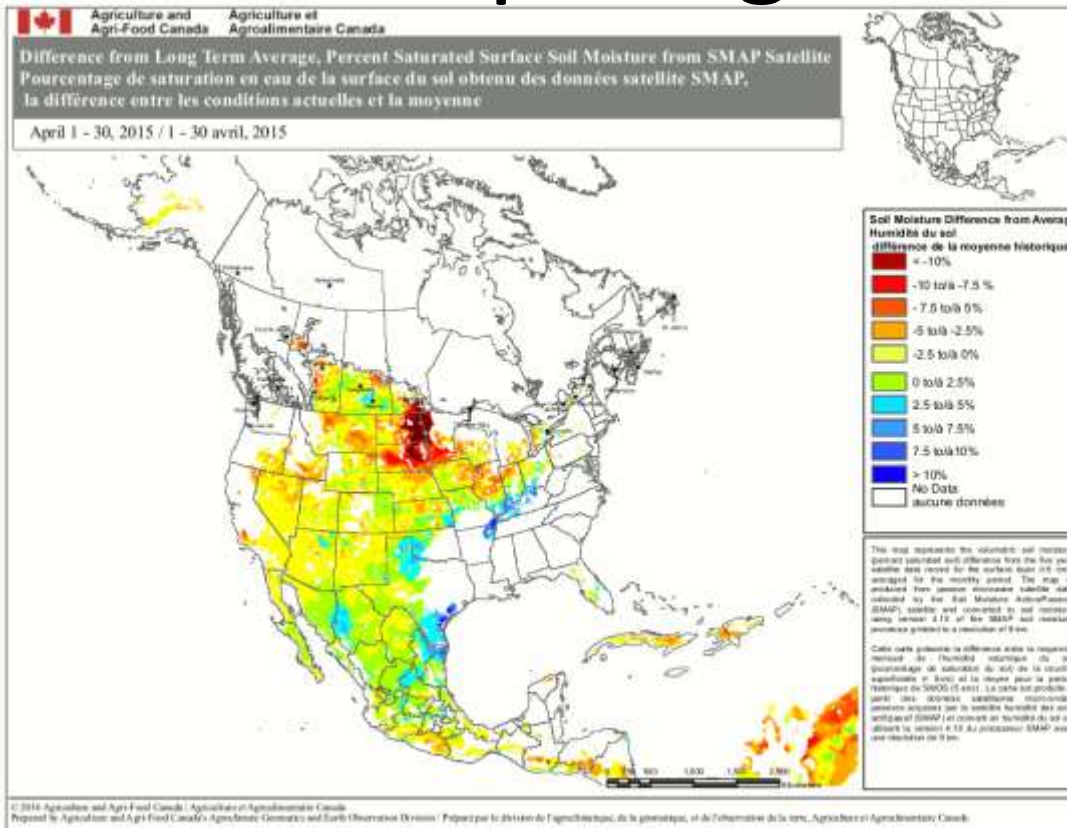
NDVI : 1984-present

Station Based Climate Indicators

Historical Crop Yield



Comparing SMOS and SMAP



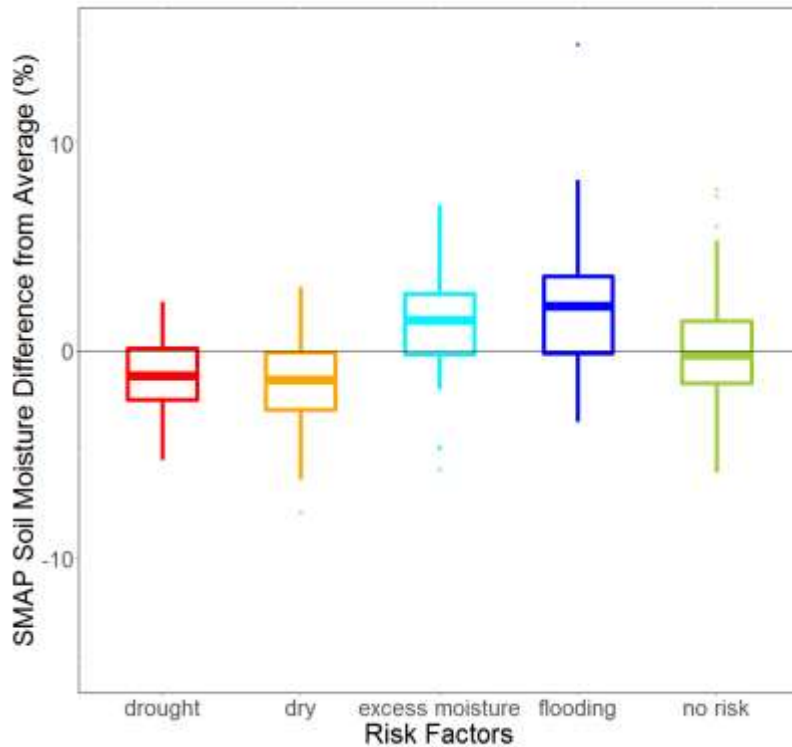
SMAP Soil Moisture (9km Passive Enhanced)

SMOS Soil Moisture (Level 2)

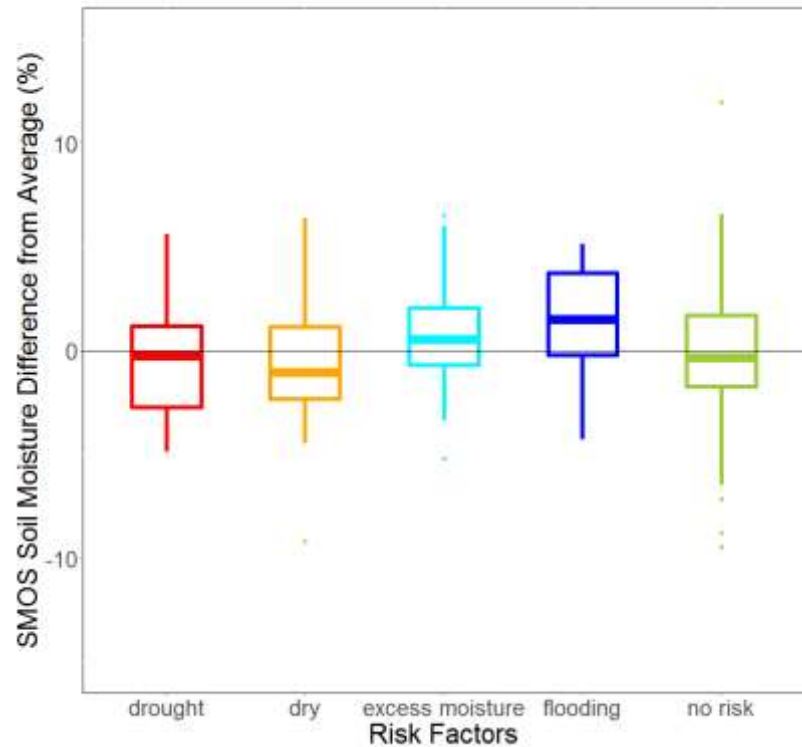
- Compare SMOS and SMAP time series
- Use SMOS history recalibrated to SMAP soil moisture to create SMAP soil moisture index
- Compared against Climate Risk Reports, Drought events and in situ stations

Quantifying Climate Related Risk

SMAP



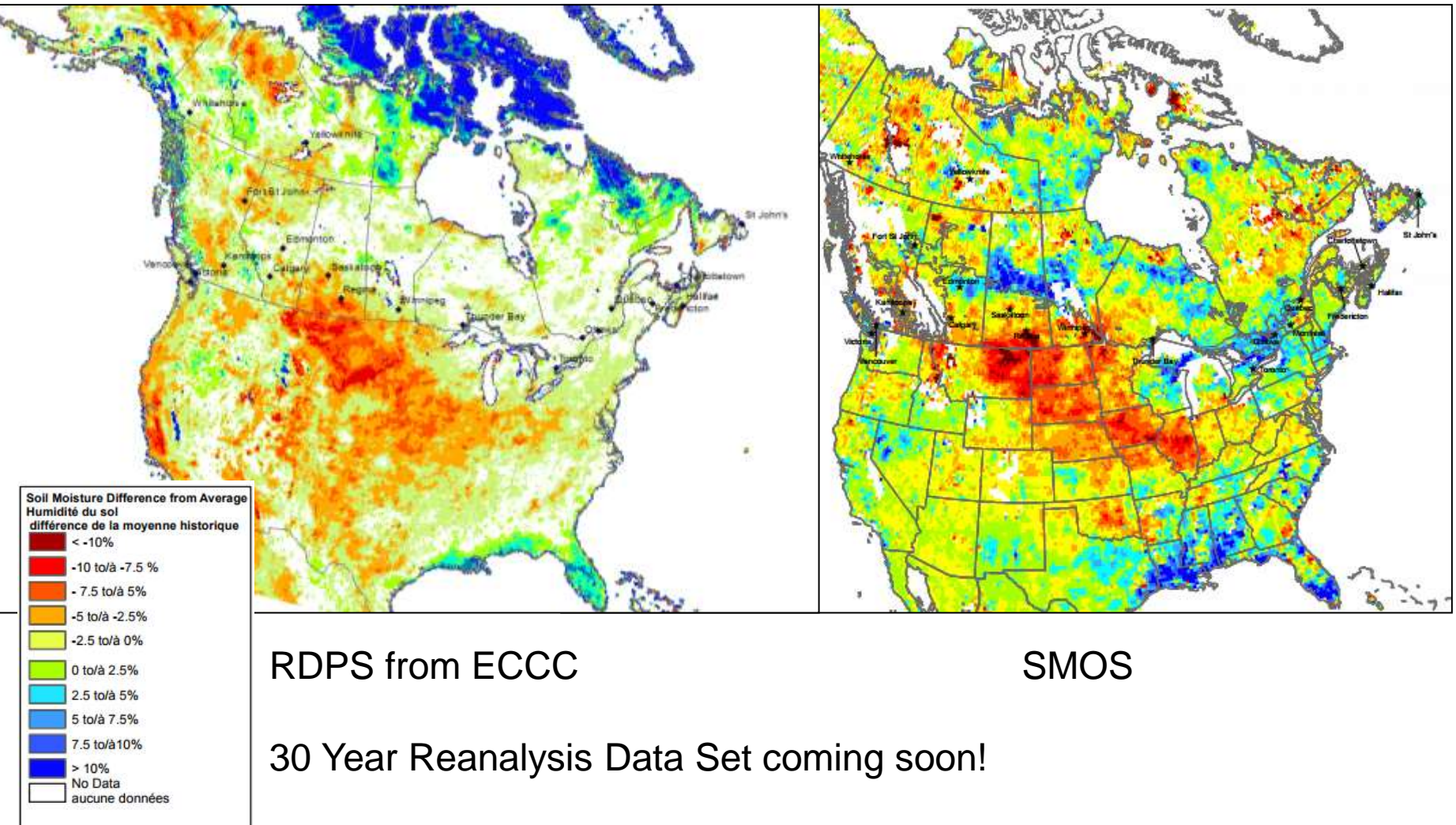
SMOS



Champagne, C.; Zhang, Y.; Cherneski, P.; Hadwen, T. Estimating Regional Scale Hydroclimatic Risk Conditions from the Soil Moisture Active-Passive (SMAP) Satellite. *Geosciences* 2018, 8, 127.

Combining Satellite and Models for Root Zone & Multi-scale Soil Moisture

Soil Moisture Difference from Average June 2017





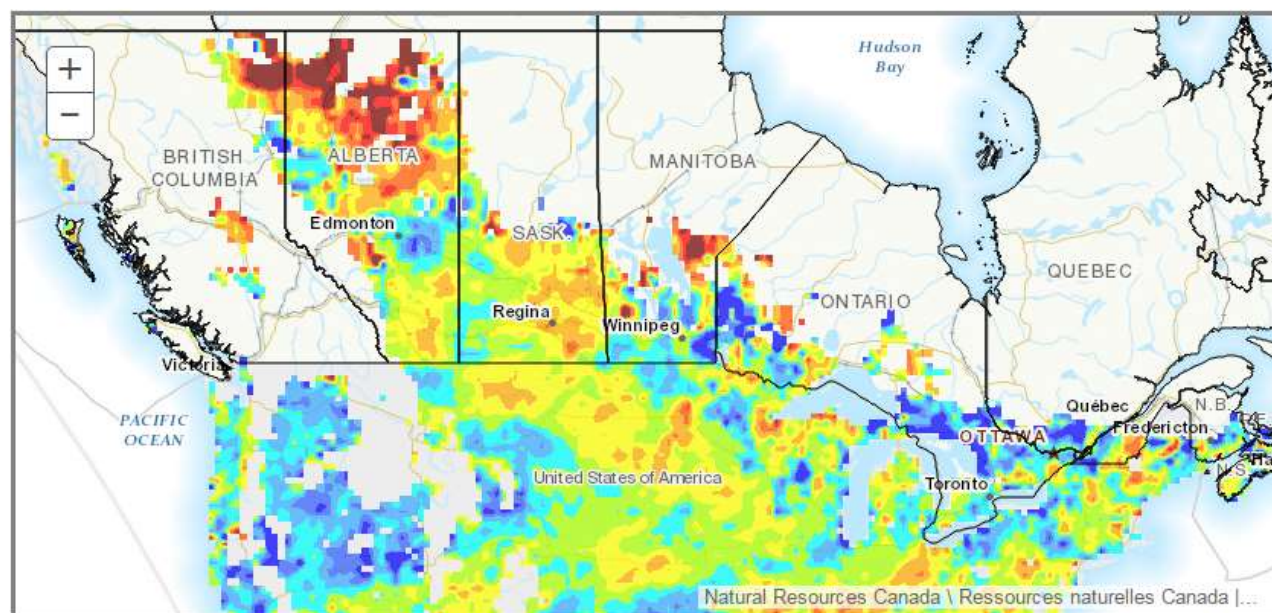
Drought Watch

[Agroclimate Maps](#)[Canadian Drought Monitor](#)[Satellite Soil Moisture](#)[Agroclimate Impact Reporter](#)[Livestock Tax Deferral
Provision](#)[Managing Agroclimate Risk](#)[Related Links](#)

Satellite Soil Moisture

The following maps and data show levels of moisture in the top five centimeters of soil in Canada on a weekly, bi-weekly and monthly basis. These information products highlight where conditions are wetter or drier than normal.

Soil moisture difference from average – interactive map showing data from previous month



Updated every
week!

► Description – Legend

Crop Metrics Application



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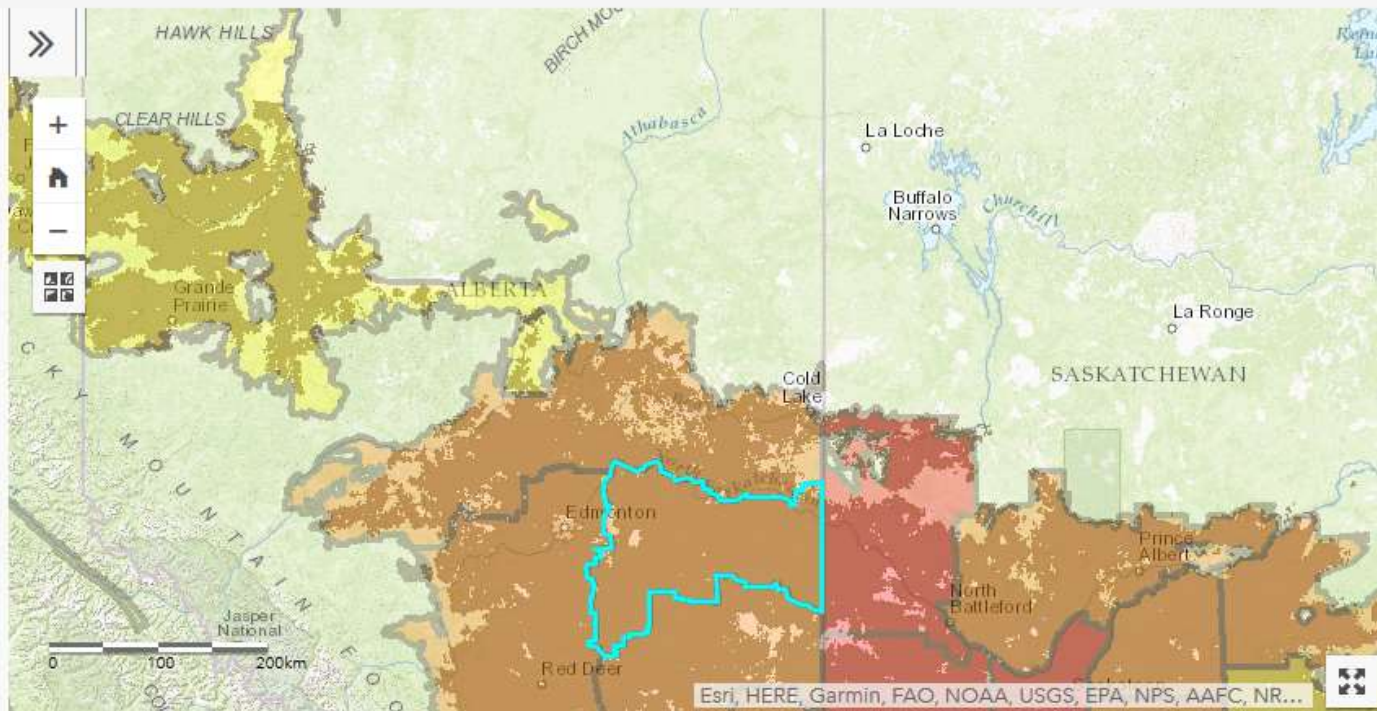
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FORECAST YIELD POTENTIAL

JULY 15, 2015

SPRING WHEAT

BEST CASE

3.5 tonnes / hectare

MOST LIKELY

2.9 tonnes / hectare

WORST CASE

2.3 tonnes / hectare

ESTIMATED CURRENT CONDITIONS

JULY 15, 2015

CROP STAGE

Emergence (Ahead)

ACCUMULATED HEAT

677 GDD (Favourable)

ACCUMULATED PRECIPITATION

76 mm (Poor)

SATELLITE VEGETATION CONDITION

-0.05 (Average)

Please select a chart :

Accumulated Heat - Line Chart



Add chart

Show all

Clear all

Want Access to Data?

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Open Data:

<http://www.agr.gc.ca/atlas/geoplatform#home>

www.data.gc.ca

Drought Watch: <http://www.agr.gc.ca/eng/?id=1326402878459>

Moving Forward

- How can we better utilize Earth Observation for Drought Monitoring & Support Drought Management?